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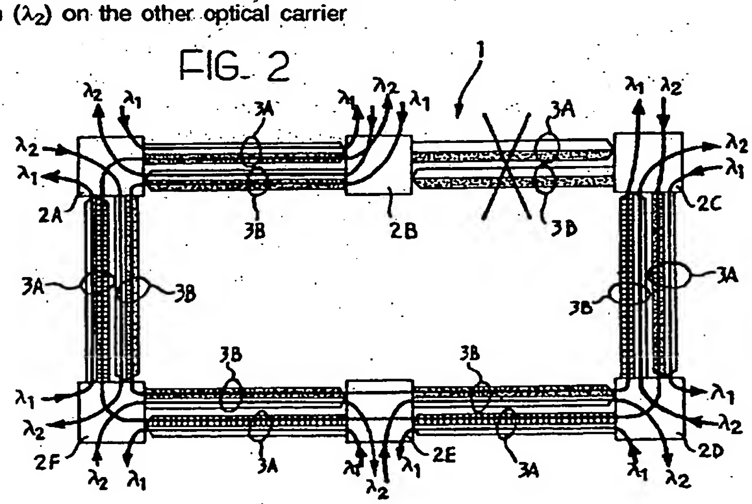
(54) Ring network communication structure on an optical carrier and reconfigurable node for said structure

(57) In a ring network communication structure for communication on an optical carrier (3A, 3B), a plurality of nodes (2A, ..., 2E) are interconnected by means of connections comprising at least a first (3A) and a second (3B) optical carrier, such as an optical fibre. Transmission occurs on the ring according to a WDM scheme, by utilising a first wavelength (λ_1) for communication in one direction on the first carrier (3A) of said pair, while communication in the opposite direction occurs by employing a second wavelength (λ_2) on the other optical carrier (3B). In the presence of a failure on one of the connections, the nodes adjacent (2B, 2C) to the failed connection reconfigure themselves to ensure the continuation of communication on the alternative path provided by the ring, by utilising the first wavelength (λ_1) on the second carrier (3B) and the second wavelength (λ_2) on the first carrier (3A). Preferential application to SDH optical fibre ring networks.

FIG. 2



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Description

The invention described herein relates to ring network communication structures and in particular it concerns a ring network communication structure in accordance with the preamble of Claim 1.

"Ring network communication structure here" means not only a communication network configured in the whole as a ring but, in general, any section of a network comprising a plurality of nodes and branches and arranged, at least temporarily, in a ring configuration.

Specifically, the present invention tackles the problem of realising a ring structure with good self-healing capabilities, i.e. good capabilities of surviving failures which may arise in the connections between the structure nodes.

"Failure" here means any event which may affect the physical carrier connecting the two nodes (e.g. breakage or interruption of an optical fibre) and/or the so-called optical terminations (i.e. the devices which generate and/or detect the optical signal), in such a way as to bring about a situation of degradation of the transmission which is deemed not tolerable; the term "failure" thus should in no way be interpreted as being limited only to events causing the complete interruption of the connection.

The present invention has been developed with particular attention to its possible application to networks which make use of SDH (Synchronous Digital Hierarchy) apparatus. The SDH structure is well known to the skilled in the art and it does not require a description here; details are reported in ITU-T Recommendation G.782.

In general, an SDH ring (it should be noted, in any case, that the field of application of the invention is not limited to this specific configuration) is made up of a set of synchronous devices capable of carrying out add-drop functions of low bit-rate signals into and from high bit-rate streams. Each node is connected to the two adjacent nodes through one or more unidirectional connections so as to form a closed path. The ring architecture allows providing protection against line and device failures and against degradation in transmission performance. In the ring, a part of the transmission capacity is dedicated to protection and therefore is not normally utilised to convey traffic. The protection capacity may possibly be used to transport very low priority traffic, which may be interrupted when a protection intervention on the ring is needed.

In ring topologies studied and realised until now, protection is accomplished by operating electrical cross-connections at the multiplex section or the path level, as described in ITU-T Recommendation G.803.

For example, in two-fibre bi-directional rings, traffic in one direction is to travel on one fibre while traffic in the opposite direction is to travel on the other fibre. Protection is achieved at the multiplex section level. These rings are also called "multiplex section shared protection rings" because, when a protection intervention is carried out in them, the transmission capacity reserved for protection is shared by the various channels to be protected.

In a two-fibre ring of this type, half the capacity of each fibre is dedicated to working traffic and the other half to protection traffic. If, for instance, each fibre conveys a 622 Mbit/s stream (defined as STM-4 in ITU-T Recommendations G708, G.709) deriving from the overlapping of four so-called administrative units (AU-4), two of these units are allotted to working traffic and two to protection traffic.

In regular operation conditions, the bi-directional communication between the two nodes utilises only the "working half" of the fibre capacity: one administrative unit for one direction and one for the other. In case of failure, the two nodes adjacent to the point where the failure has occurred re-route the traffic of the working part of each fibre on the protection part of the other fibre, where transmission occurs in the opposite direction. The remaining nodes of the ring do not carry out any re-routing and continue to operate as they did before the failure onset.

The ring reconfiguration, when performed electrically, implies an inefficient exploitation of the available resources since half of the administrative units are intended for protection.

There is, then, a perceived requirement to have the possibility of carrying out a reconfiguration intervention on the ring structure optically, what would allow full exploitation of the transmission capacity.

The aim of the present invention is to provide a ring network structure and a node for such a structure which meets the aforesaid requirement.

According to the present invention, this aim is attained thanks to a ring network structure with the characteristics specifically recited in claims 1 to 3. The invention concerns also a reconfigurable node for a ring network structure of the type specified above, with the characteristics recited in claims 4 to 10.

In practice, the solution according to the invention allows a protection at the optical carrier level, which protection is carried out by utilising Wavelength Division Multiplexing (WDM) techniques and space switching of the signals. As previously stated, the invention is particularly advantageous if applied to signals carrying SDH frames. The same considerations, however, can also be made with other transmission formats, such as the formats known in the art as PDH (Plesiochronous Digital Hierarchy) or ATM (Asynchronous Transfer Mode), or analog formats, etc.

The invention will now be described, solely by way of non-limiting example, with reference to the enclosed drawings, in which:

- Figure 1 shows the outline of the configuration of a ring network communication structure according to the invention, under regular operation conditions;
- Figure 2 shows the outline of the same structure as in Figure 1, as reconfigured in the presence of a failure on one of the connections between the nodes,

- Figure 3 shows one of the nodes of the network according to the invention under regular operation conditions,
- Figures 4 and 5 show the manner in which the node shown in Figure 3 is reconfigured to take into account a failure occurred on either connection terminating at the node (East side - West side), and
- Figure 6 shows the operation of the node shown in Figure 3 in the presence of a failure that does not affect the connections terminating at the node.

In the drawings, a communication structure over an optical carrier (optical fibre) organised according to a general ring configuration is indicated in the whole as 1. As stated in the introduction of the present description, the solution according to the invention is suitable for being used, substantially without changes, both for networks which in the whole present a ring configuration and for those elements of a network of any kind that are configured, albeit only temporarily, as a ring.

Structure 1 thus comprises a number of nodes connected to each other in pairs through bi-directional connections. By way of example, Figure 1 refers to a structure comprising six nodes which are denoted, in sequence, 2A, 2B, 2C, 2D, 2E and 2F and are connected in pairs by two optical carriers here shown schematically as a first and a second optical fibre 3A, 3B: such reference numerals are maintained unaltered for the two fibres throughout the ring structure.

The reference to connections comprising two optical fibres is to be considered merely as an example, as the solution according to the invention is also suitable for utilisation in ring structures in which the nodes are connected by a larger number of optical carriers.

According to an important characteristic of the solution according to the invention, communication over optical carriers 3A and 3B is achieved according to a Wavelength Division Multiplexing (WDM) scheme utilising different wavelengths on the two fibres.

In the embodiment illustrated schematically in Figure 1, a wavelength λ_1 is utilised on fibre 3A for the working traffic (hereinafter also called simply "traffic"), travelling clockwise (of course, reference is made to the conditions of observation of the network in Figure 1). A wavelength λ_2 is utilised instead on fibre 3B for the traffic in the opposite direction (counterclockwise).

Under regular operation conditions of the network, in each node the signals conveyed by the two fibres are detected, processed as required in units of a higher hierarchical level, converted again into optical signals and re-transmitted towards the following node.

With regard to the protection function, instead, the configuration is exactly opposite: wavelength λ_2 is used on fibre 3A and wavelength λ_1 on fibre 3B. Such different allocation of wavelengths λ_1 and λ_2 to working traffic and protection traffic has been shown schematically in the enclosed drawings by representing with dots the part of each fibre 3A, 3B dedicated to the protection function. The part intended for conveying traffic under regular operation conditions, is shown with no dots.

The specific design features of individual nodes 2A...2F, which features allow the operation just described to be accomplished, shall be illustrated in more detail in what follows. In any case it should be recalled that the modalities for selecting the wavelengths for transmission, even within a WDM scheme, and the criteria to put such modalities into effect within the individual nodes are widely known in the art and need not be described in detail here, especially since - in themselves - they are not of relevance for the invention.

It must also be stated that the WDM transmission scheme described above with reference to two wavelengths λ_1 and λ_2 can be generalised to any number of wavelengths. Essentially, as will be shown more specifically further on, it is generally sufficient that, if a wavelength $l_i(i = 1...N)$ is normally used for traffic on one of the fibres (e.g. fibre 3A), the same wavelength l_i should be reserved for protection on the other fibre (in this case, fibre 3B).

Figure 2 schematically shows the criteria according to which the reconfiguration of ring structure 1 in the presence of a failure on one of the connections is accomplished: specifically, Figure 2 refers to the connection between nodes 2B and 2C. Under such conditions, traffic at wavelength λ_1 which should propagate (through the failed connection) from node 2B towards node 2C on fibre 3A is sent towards node 2A by utilising wavelength λ_1 available for protection on the other fibre (in the example shown, fibre 3B). In the opposite direction, traffic at wavelength λ_2 which should propagate (through the failed connection) from node 2C towards node 2B on fibre 3B is sent towards node 2D by utilising wavelength λ_2 available for protection on the other fibre (in this case, fibre 3A).

This determines the presence at node 2B of a stream of incoming traffic at wavelength λ_2 (utilised as protection wavelength on fibre 3A): this traffic, as well as the traffic which has possibly been generated in node 2B and which is to be transmitted at wavelength λ_2, are sent back towards node 2A by utilising traffic wavelength λ_2 on fibre 3B. The same thing occurs in correspondence of node 2C, where incoming traffic at wavelength λ_1 (protection wavelength on fibre 3B), as well as traffic generated in node 2C and to be transmitted at wavelength λ_1, are sent towards node 2D by utilising traffic wavelength λ_1 on fibre 3A.

This protection method provides a ring configuration which is similar to the one that can be obtained when the protection is carried out at multiplex section level with SDH transmission techniques, but which avoids halving the transport capacity of the STM stream. A remarkable synergy effect between SDH multiplexing and optical protection can be obtained if, in correspondence with each node, a signal insertion-extraction device (ADM device or Add-Drop Multiplexer) is provided, having East and West interfaces connected to the fibres going into and coming out of the optical node. In this case the ring

can function at full capacity both in regular operation conditions and in the presence of failures.

The redundancy needed for protection is thus shifted from the SDH level to the optical level, by utilising a plurality of wavelengths. Obtaining the features required for the ring operation requires, from the system standpoint, the integration of a relatively small number of passive optical components. The ring protection and reconfiguration functions take place by utilising multiplexing and routing on the basis of the wavelength and they are obtained by means of the combined use of wavelength demultiplexers, waveguide space switches and fibre couplers: such components are widely known in the art and commercially available.

Figure 3 illustrates, in the form of a block diagram, the typical configuration of one of the nodes of ring structure 1 under regular operation conditions. The illustrated example concems specifically node 2B.

The block diagram in Figure 3 (and also in the corresponding outlines of Figures 4 to 6) shows that the optical fibres which - under regular operation conditions - convey incoming traffic (fibre 3A on the left side, conventionally indicated as West side, and fibre 3B on the right side, conventionally indicated as East side) are each connected to a respective wavelength demultiplexer 10A and 10B. Demultiplexers 10A and 10B are connected to respective space switches 11A, 11B (first switching stage), which consist for instance of thermo-optical or opto-mechanical switches and which, in the exemplary embodiment shown, are taken to be 2x2 switches: the same configuration can however be realised by means of switches with a larger number of inputs/outputs to reduce the number of components. Two similar switches 12A and 12B (second switching stage) are associated, through respective wavelength multiplexers 120A and 120B, to the fibres which convey traffic outgoing from the node (fibre 3A on the right or East side, and fibre 3B on the left or West side).

Respective transmitter/receiver groups of an ADM device indicated in the whole as 13 are connected to switches 11A, 11B, 12A and 12B. More specifically, there are provided a transmitter/receiver group operating - under regular operation conditions - on the West side and comprising a receiver 14A and a transmitter 14B, and an analogous transmitter/receiver group operating - again under regular operation conditions - on the East side and comprising a transmitter 15A and a receiver 15B.

Since, under regular operation conditions, wavelength λ_1 is used in one direction (clockwise in Figure 1) for communication on the ring and wavelength λ_2 is used in the opposite direction (counterclockwise in Figure 1), receiver 14A and transmitter 15A operate at wavelength λ_1, while transmitter 14B and receiver 15B operate at wavelength λ_2.

All the components described with reference to the structure of the node shown in Figure 3 are widely known and commercially available. ADM device 13 can be for instance device MSH11 manufactured by Marconi, where the receiver/transmitter groups 14A, 14B and 15A, 15B operate at wavelengths λ_1, λ_2 lying, for instance, in the so-called third window (wavelengths of around 1550 nanometres).

It is suitable to stress yet again that the exemplary embodiment described herein with reference to just two wavelengths λ_1, λ_2 can be generalised to any number of wavelengths with a corresponding expansion of the connection structure illustrated in Figures 3 to 6: in that case, switching matrices of the nxn type may be used.

Returning to the detailed description of the outline in Figure 3 (which refers to the configuration of node 2B under regular operation conditions of the ring structure, in which the communication takes place in one direction by utilising wavelength λ_1 on fibre 3A and in the opposite direction by utilising wavelength λ_2 on the other fibre 3B, while wavelength λ_2 on fibre 3A and wavelength λ_1 on fibre 3B are reserved for protection), it can be noted that traffic at wavelength λ_1 arriving at node 2B on fibre 3A on the West side, goes through demultiplexer 10A and switch 11A, and then enters ADM device 13 through receiver 14A operating at wavelength λ_1. Outgoing traffic on the East side at the same wavelength is emitted by ADM device 13 through transmitter 15A, then goes through switch 12B and is injected into fibre 3A on the East side through multiplexer 120A.

In a complementary way, incoming traffic at wavelength on the East side on fibre 3B goes through demultiplexer 10B and switch 11B, and then enters ADM device 13 through receiver 15B operating at wavelength λ_2. Outgoing traffic on the West side at wavelength λ_2 leaves ADM device 13 through transmitter 14B, then goes through switch 12A and it is injected into fibre 3B on the West side through multiplexer 120B.

Cross-connections between switches 11A, 11B, 12A and 12B, (indicated as thin lines in the schematic drawing in Figure 3) remain therefore inactive.

The configuration described above is repeated in an analogous way for all the nodes in the ring structure.

Figures 4 and 5 illustrate instead the reconfiguration of nodes 2B and 2C in the presence of a failure (for the meaning of the term "failure", see the terminology foreword in the introductory part of the present description) which here is assumed to have occurred, as outlined in Figure 2, in the ring section between nodes 2B and 2C, thus, respectively, on the East side for node 2B and on the West side for node 2C.

The onset of the failure is detected in correspondence of the various nodes of the network by using techniques which do not require to be specifically illustrated here (for instance, techniques based on the detection of pilot tones, see the article by G. R. Hill et al., "A Transport Network Layer Based on Optical Network Elements", Journal of Lightwave Technology, Vol. 11, no. 5/6, May-June 1993): besides, the nature and the characteristics of such techniques for failure detection and transmission of information on the failure are not, in themselves, of importance for the comprehension and the realization of the invention.

The failure occurrence on the East side results, with regard to node 2B, in the impossibility of transmitting and receiving information on fibres 3A and 3B which are on the East side of the node.

In this respect, it should be noted that - strictly speaking - the failure could actually concern just one of the fibres or optical carriers 3A, 3B (or the related optical terminations); in any case, the reconfiguration solution according to the present invention allows carrying out a protection intervention by considering as inactive all fibres or optical carriers included in the connection in which the failure has occurred. This solution allows, for example, the failure to be repaired while the connection is fully cut-off, so that one must not worry about possibly disturbing, as an effect of the repair interventions on a failure, a communication which continues on the other carrier(s) included in the same connection.

In the specific case shown in Figure 4 (reconfiguration of node 2B which has the failure on its East side), the protection intervention is effected by switching switches 11B and 12B. This means that switches 11A and 12A maintain the positions illustrated above, so as to route towards receiver 14A traffic at wavelength λ_1 coming on fibre 3A on the West side and to send towards fibre 3B on the West side traffic coming from ADM device 13 through transmitter 14B, operating at wavelength λ_2. Switch 11B instead is switched so as to cut-off the connection with multiplexer 10B (which in fact is inactive since it is connected to fibre 3B on the failed East side) and thereby to receive traffic at wavelength λ_2 (protection wavelength on fibre 3A) coming on fibre 3A on the West side through demultiplexer 10A. Then the traffic itself is routed towards receiver 15B operating at wavelength λ_2.

Analogously, traffic at wavelength λ_1 generated by transmitter 15A is sent to switch 12B which, instead of transmitting it towards fibre 3A on the East side - as was the case previously (Figure 3) - routes it towards fibre 3B on the West side through multiplexer 120B, while multiplexer 120A is in fact inactive.

Figure 5 shows the similar and essentially complementary reconfiguration accomplished at node 2C, i.e. at the node which has the failure on its West side. In this case the switching concerns switches 11A and 12A, while switches 11B and 12B maintain the regular operation configuration. In this case, demultiplexer 10A is inactive and incoming traffic at working wavelength λ_2 on fibre 3B on the East side goes through demultiplexer 10B and switch 11B (which has not been switched) towards receiver 15B as before. Analogously, traffic at wavelength λ_1 coming out of transmitter 15A goes through switch 12B and multiplexer 120A to reach fibre 3A on the East side. On the contrary, incoming traffic at wavelength λ_1 (protection wavelength) on fibre 3B on the East side goes through demultiplexer 10B and switch 11A (which has been switched) and then arrives at receiver 14A. In a complementary way, traffic coming out of transmitter 14B operating at wavelength λ_2 goes through switch 12A (switched) and hence to multiplexer 120A and to fibre 3A (with respect to which wavelength λ_2 constitutes the protection wavelength) on the East side. In these conditions, both demultiplexer 10A and multiplexer 120B are inactive.

From a comparison between Figure 3 (which illustrates the configuration of any one of the network nodes under regular operation conditions) and Figure 6 (which illustrates the operating conditions - in the presence of a failure - of the ring nodes other than nodes 2B and 2C directly involved in the failure), one can readily understand how the reconfiguration of the ring to a protection condition affects only the nodes immediately adjacent to the failure (thus nodes 2B and 2C in the exemplary embodiment shown) and requires neither reconfiguring the other nodes nor the intervention of the other ADM devices which are left undisturbed. In the optical layer of the node this is possible due to the transparency to the protection signals which just transit through the various components of the node and by-pass the ADM device as shown in Figure 6.

Specifically, Figure 6 shows (with reference to node 2E, by way of example) that, in the presence of a failure on the connection between nodes 2B and 2C (which are reconfigured as previously described) incoming traffic at wavelength λ_1 on the West side on fibre 3A goes through demultiplexer 10A, switch 11A and receiver 14A as under regular operation conditions. Traffic coming out of transmitter 15A, again at wavelength λ_1, goes to multiplexer 120A through switch 12B which routes it towards fibre 3A on the East side as under regular operation conditions. Incoming traffic on the East side at wavelength λ_2 goes through demultiplexer 10B and switch 11B, arriving at receiver 15B, again totally as in the case of regular operation conditions. Analogously, outgoing traffic on the West side (fibre 3B) at wavelength λ_2 leaves transmitter 14B to pass through switch 12A and from this on fibre 3B on the West side through multiplexer 120B.

The effect of the reconfiguration (it should be recalled that the reconfiguration of nodes 2B and 2C, directly involved in the failure, is being discussed) affects the other nodes such as node 2E illustrated in Figure 6 in that, on the West side, these other nodes see incoming traffic on fibre 3A also at wavelength λ_2 and emit outgoing traffic on fibre 3B also at wavelength λ_1. On the East side, the same nodes see the incoming traffic on fibre 3B also at wavelength λ_1 and emit outgoing traffic on fibre 3A also at wavelength λ_2.

Incoming traffic at wavelength λ_2 on fibre 3A on the West side goes through demultiplexer 10A, hence to switch 11B and to switch 12A and passes, still at wavelength λ_2, on fibre 3A on the East side through multiplexer 120A. Incoming traffic at wavelength λ_1 on the East side on fibre 3B goes through demultiplexer 10B, hence to switch 11A and to switch 12B and then passes, still at wavelength λ_1, on fibre 3B on the West side through multiplexer 120B. Traffic coming out of the node (transmitter 15A at wavelength λ_1 and transmitter 14B at wavelength λ_2 is regularly routed towards fibre 3A on the East side and towards fibre 3B on the West side.

When the reconfiguration is carried out, the node architecture according to the invention allows sharing and multiplexing of the signals on the node input(output fibres, guaranteeing the transmission continuity.

Choosing both wavelengths λ_1, λ_2 within the third window is preferable because of the possibility of employing EDFA (Erbium Doped Fibre Amplifiers) optical amplifiers to recover any signal losses which can occur, at the reconfiguration, because of the passage through the nodes on the protection path and of the greater overall length of the fibre section.

Of course, while the principle of the invention remains constant, details of its embodiment and the forms in which it is put in practice can widely vary with respect to what has been described and illustrated, without departing from the scope of the present invention.

Claims

1. Ring network communication structure (1) comprising a plurality of nodes (2A, ..., 2F) connected to each other in pairs by means of respective connections susceptible to failure, in which each connection comprises at least one first (3A) and one second (3B) optical carrier, characterized in that for communication on said ring structure there is utilised, in one direction, at least a first wavelength (λ_1) on said at least one first optical carrier (3A) and, for communication in the opposite direction, at least a second wavelength (λ_2) on said at least one second optical carrier (3B), and in that, in the presence of a failure on one of said connections (3A, 3B), the nodes (2B, 2C) adjacent to the failed connection are so reconfigured as to utilise, to communicate with each other, said at least one first wavelength (λ_1) on said at least one second optical carrier (3B) and said at least one second wavelength (λ_2) on said at least one first optical carrier (3A).

2. Communication structure as claimed in claim 1, characterized in that, in the absence of failures, said at least one first wavelength (λ_1) on said at least one second optical carrier (3B) and said at least one second wavelength (λ_2) on said at least one first optical carrier (3A), are utilised as protection wavelengths to transport low-priority traffic.

3. Communication structure as claimed in any of the previous claims, characterized in that at least some of said nodes (2A, ..., 2F) comprise signal insertion-extraction devices (13).

4. Reconfigurable node for a ring network communication structure, said node presenting a first and a second side where a respective connection ends, each connection comprising at least one first (3A) and one second (3B) optical carrier, characterized in that the node comprises:

   - first (10A) and second (10B) wavelength demultiplexing means operating at said at least one first (λ_1) and one second (λ_2) wavelength and associated respectively to said at least one first optical carrier (3A) on said first side and to said at least one second optical carrier (3B) on said second side,
   - first (120A) and second (120B) wavelength multiplexing means operating at said at least one first (λ_1) and one second (λ_2) wavelength and associated respectively to said at least one first optical carrier (3A) on said second side and to said at least one second optical carrier (3B) on said first side, and
   - optical signal switching means (11A, 11B, 12A, 12B) connected between said first (10A) and a second (10B) demultiplexing means and said first (120A) and second (120B) multiplexing means; said switching means (11A, 11B, 12A, 12B) being selectively reconfigurable between a regular operation configuration, at least one first protection configuration, which can be adopted in the presence of a failure on the respective connection on said second side, and at least one second protection configuration, which can be adopted in the presence of a failure on the respective connection on said first side.

5. Node as claimed in claim 4, characterized in that said switching means (11A, 11B, 12A, 12B) are reconfigurable so that:

   - in said regular operation configuration, said first (10A) and second (10B) demultiplexing means as well as said first (120A) and second (120B) multiplexing means are active, the incoming optical signals at said at least one first wavelength (λ_1) present on said at least one first carrier (3A) on said first side pass to said at least one first carrier (3A) on said second side, through said first demultiplexing means (10A), said switching means (11A, 12A) and said first multiplexing means (120A), and the incoming optical signals at said at least one second wavelength (λ_2) present on said at least one second carrier (3B) on said second side pass to said at least one second carrier (3B) on said first side, through said second demultiplexing means (10B), said switching means (11B, 12B) and said second multiplexing means (120B),
   - in said first protection configuration, said second demultiplexing means (10B) and said first multiplexing means (120A) are inactive and incoming signals at said at least one first (λ_1) and one second (λ_2) wavelength, present on said at least one first carrier (3A) on said first side, pass to said at least one second carrier (3B) on said first side through said first demul-

tiplexing means (10A), said switching means (11A, 12B), and said second multiplexing means (120B),

- in said second protection configuration, said first demultiplexing means (10A) and said second multiplexing means (120B) are inactive, and incoming signals at said at least one first (λ_1) and one second (λ_2) wavelength, present on said at least one second carrier (3A) on said second side, pass to said at least one first carrier (3A) on said second side through said second demultiplexing means (10A), said switching means (11A, 12B) and said first multiplexing means (120B).

6. Node as claimed in claim 4 or claim 5, characterized in that said first and second demultiplexing means (10A, 10B), said switching means (11A, 11B, 12A, 12B) and said first and second multiplexing means (120A, 120B) operate in such a way that, in the presence of a failure on a connection not adjacent to the node itself, the incoming signals at said at least one first (λ_1) and one second (λ_2) wavelength, present on said at least one first carrier (3A) on said first side, pass to said at least one first carrier (3A) on said second side through said first multiplexing means (120A), while the incoming signals at said at least one first (λ_1) and one second wavelength (λ_2), present on said at least one second carrier (3B) on said second side, pass to said at least one second carrier (3B) on said first side through said second demultiplexing means (10B), said switching means (11A, 11B, 12A, 12B) and said second multiplexing means (120B).

7. Node as claimed in any one of claims 4 to 6, characterized in that said switching means comprise:

- at least one first switch (11A) operating between said first demultiplexing means (10A) and said first multiplexing means (120A) in said regular operation configuration and in said at least a first protection configuration; said at least one first switch (11A) operating instead between said second demultiplexing means (10B) and said first multiplexing means (120A) in said at least one second protection configuration; and
- at least one second switch (11B) operating between said second demultiplexing means (10B) and said second multiplexing means (120B) in said regular operation configuration and in said at least one second protection configuration; said at least one second switch (11B) operating instead between said first demultiplexing means (10A) and said second multiplexing means (120B) in said at least one first protection configuration.

8. Node as claimed in any one of claims 4 to 7, characterized in that it comprises a signal insertion and extraction device (13) including first receiving means (14A) and first transmitting means (15A) operating at said at least one first wavelength (λ_1), and second receiving means (15B) and second transmitting means (14B) operating at said at least one second wavelength (λ_2), and in that said switching means comprise at least one first switching stage (11A, 11B) arranged to operate between whichever of said first (10A) and said second (10B) demultiplexing means is currently active and said first (14A) and second (15B) receiving means, and a second switching stage (12A, 12B) arranged to operate between said first (15A) and second (14B) transmitting means and at least one of said first (120A) and said second (120B) multiplexing means which is currently active.

9. Node as claimed in claim 8, characterized in that, in said regular operation configuration, said first switching stage (11A, 11B) conveys respective signals from said first (10A) and second (10B) demultiplexing means towards respective first (14A) and second (15B) receiving means, while in said at least one first and one second protection configuration said first switching stage (11A, 11B) conveys said respective signals from whichever of said first (10A) and second (10B) demultiplexing means is currently active towards respective first (14A) and second (15B) receiving means.

10. Node as claimed in claim 8 or claim 9, characterized in that in said regular operation configuration, said second switching stage (12A, 12B) conveys respectively signals between said first (15A) and second (14B) transmitting means and said first (120A) and second (120B) multiplexing means, while in said at least one first and one second protection configuration, said second switching stage (12A, 12B) conveys said respective signals between said first (15A) and second (14B) transmitting means and whichever of said first (120A) and second (120B) multiplexing means is currently active.

FIG. 1

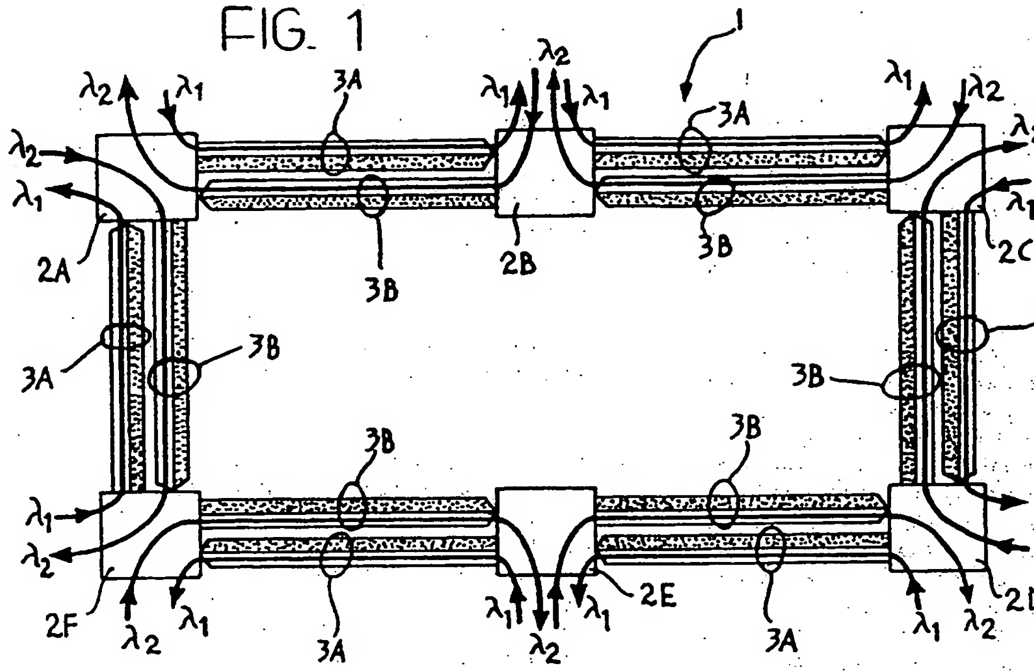

1
λ2
λ1
λ2
λ1
3A
3B
2A
2B
2C
2D
2E
2F
3A
3B

FIG. 2

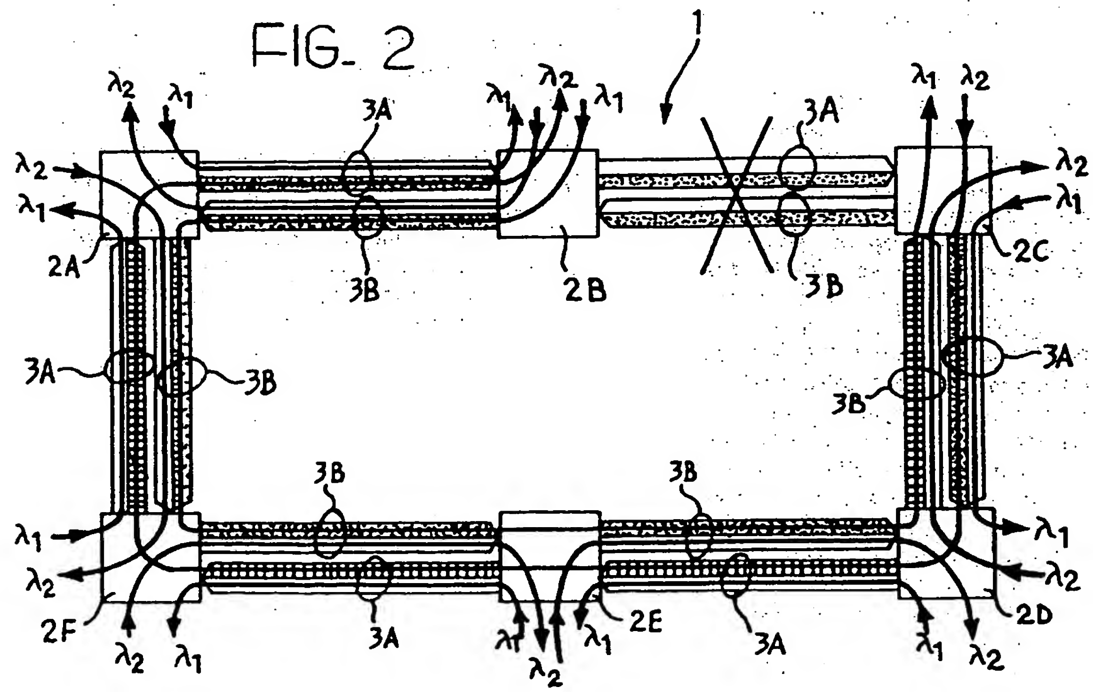

1
λ2
λ1
λ2
λ1
3A
3B
2A
2B
2C
2D
2E
2F
3A
3B

FIG. 3

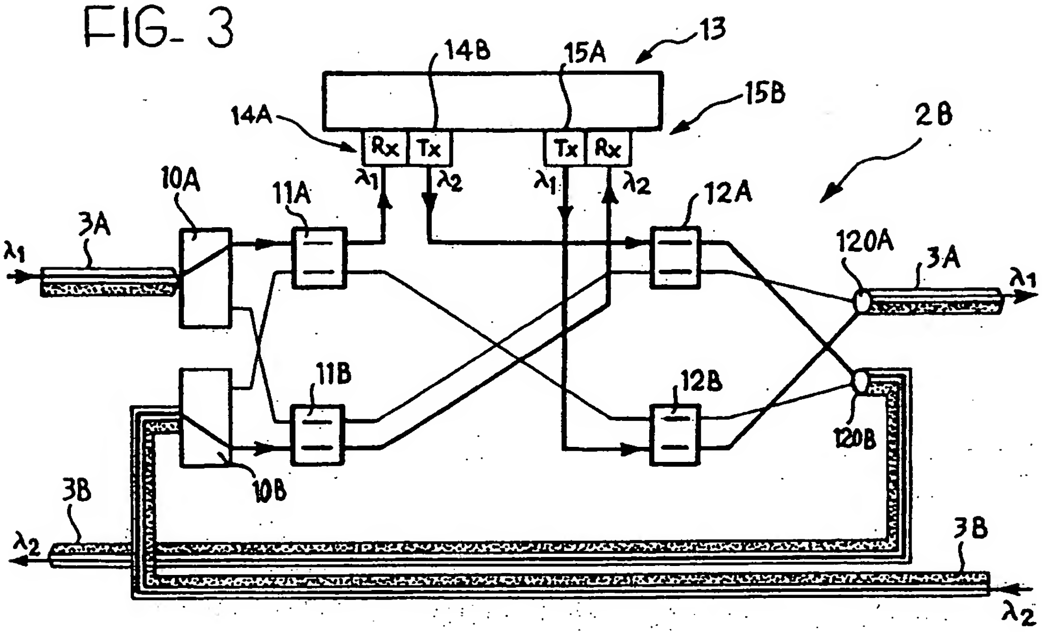

13
14B
15A
15B
14A
Rx
Tx
Tx
Rx
2B
λ1
λ2
λ1
λ2
10A
11A
12A
3A
λ1
120A
3A
λ1
11B
12B
120B
3B
10B
λ2
3B
λ2

FIG. 4

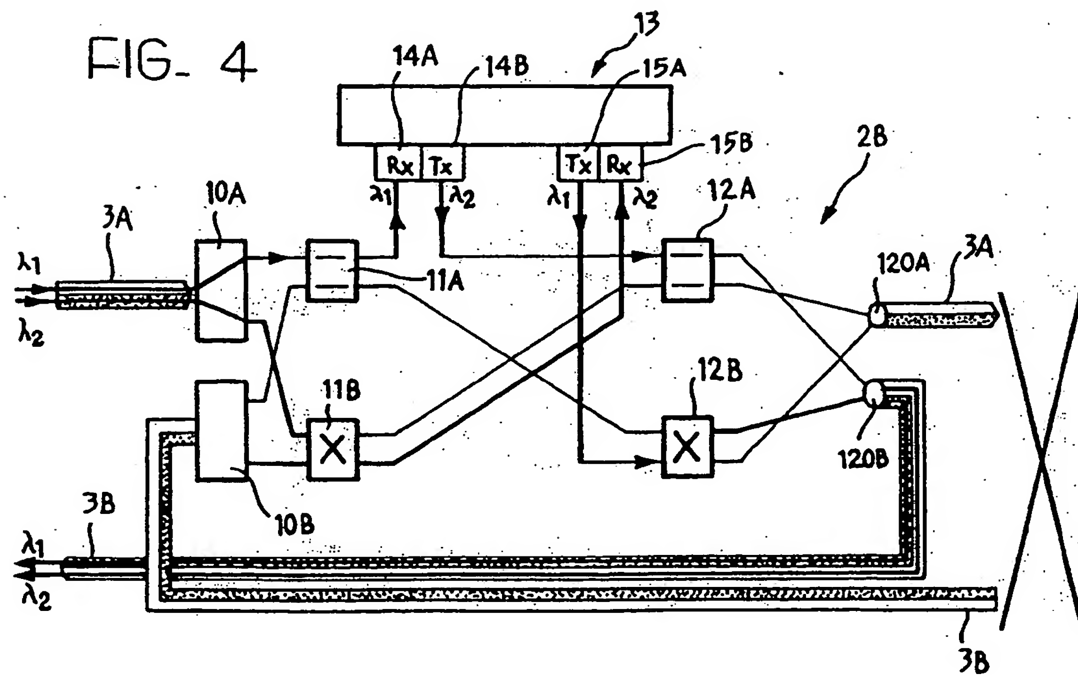

13
14A
14B
15A
15B
Rx
Tx
Tx
Rx
2B
10A
λ1
λ2
λ1
λ2
12A
3A
λ1
λ2
11A
120A
3A
11B
12B
120B
3B
λ1
λ2
10B
3B

FIG. 5

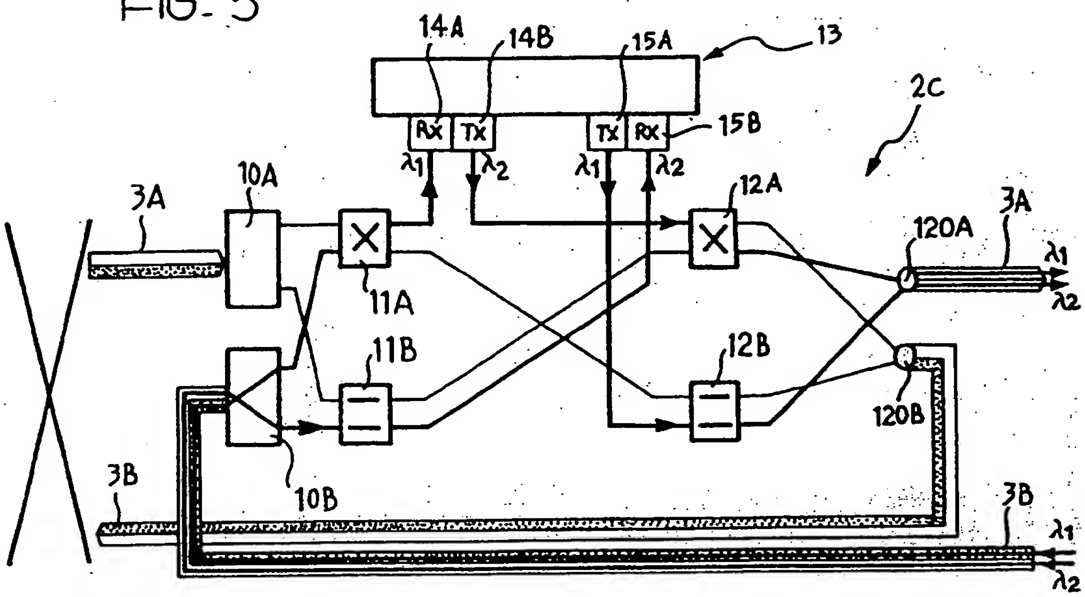
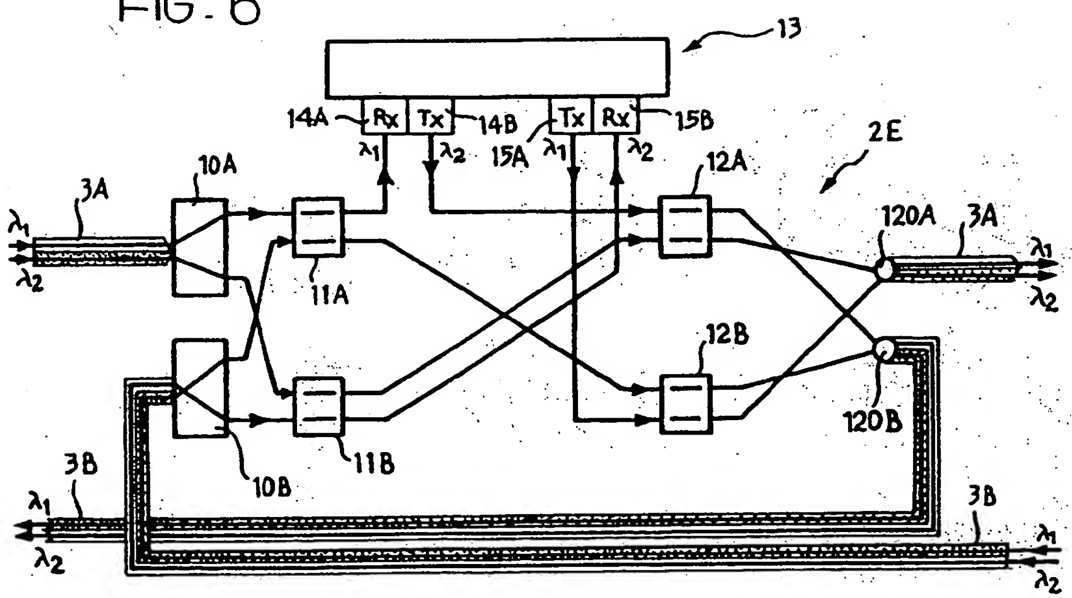

14A
14B
15A
13
2C
RX
TX
TX
RX
15B
λ1
λ2
λ1
λ2
10A
3A
12A
3A
120A
λ1
λ2
11A
11B
12B
120B
3B
10B
3B
λ1
λ2

FIG. 6


13
14A
Rx
Tx
14B
Tx
Rx
15B
2E
λ1
λ2
15A
λ1
λ2
10A
12A
3A
λ1
λ2
120A
3A
λ1
λ2
11A
12B
120B
11B
10B
3B
λ1
λ2
3B
λ1
λ2

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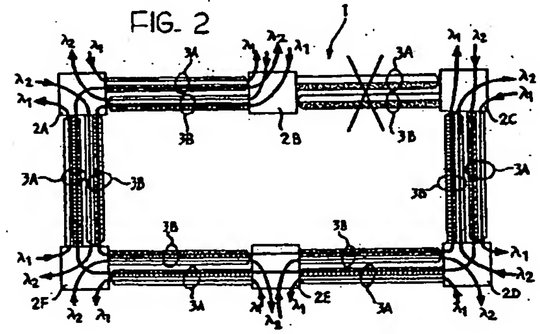
(54) Ring network communication structure on an optical carrier and reconfigurable node for said structure

(57) In a ring network communication structure for communication on an optical carrier (3A, 3B), a plurality of nodes (2A, ..., 2E) are interconnected by means of connections comprising at least a first (3A) and a second (3B) optical carrier, such as an optical fibre. Transmission occurs on the ring according to a WDM scheme, by utilising a first wavelength (λ_1) for communication in one direction on the first carrier (3A) of said pair, while communication in the opposite direction occurs by employing a second wavelength (λ_2) on the other optical carrier (3B). In the presence of a failure on one of the connections, the nodes adjacent (2B, 2C) to the failed connection reconfigure themselves to ensure the continuation of communication on the alternative path provided by the ring, by utilising the first wavelength (λ_1) on the second carrier (3B) and the second wavelength (λ_2) on the first carrier (3A). Preferential application to SDH optical fibre ring networks.

FIG. 2



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Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	US 5 159 595 A (FLANAGAN THOMAS P J ET AL) * column 1, line 9-12 * * column 2, line 4-26 * * column 3, line 63-66 * * column 10, line 23 - column 11, line 35; figure 6 * * column 13, line 17-58; figure 10 * ---	1-6	H04J14/02 H04Q11/00 H04B10/213
A	PATENT ABSTRACTS OF JAPAN vol. 018, no. 364 (E-1575), 8 July 1994 & JP 06 097950 A (OKI ELECTRIC IND CO LTD), 8 April 1994, * abstract * ---	1,4	
A	ELREFAIE A F: "MULTIWAVELENGTH SURVIVABLE RING NETWORK ARCHITECTURES" PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON COMMUNICATIONS (ICC), GENEVA, MAY 23 - 26, 1993, vol. VOL. 2, no. -, 23 May 1993, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, pages 1245-1251, XP000371271 * page 1246, left-hand column, line 42-45; figure 5 * * page 1246, right-hand column, line 21-27; figure 6 * * page 1247, right-hand column, line 13-31; figure 9 * * page 1248, left-hand column, line 1-6 * -----	1,4	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H04J H04Q H04B H04L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 April 1998	Traverso, A

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